REMARKS

Applicants have amended the claims to include a method claim to the method aspect of the presently claimed invention as fully supported by Applicants' specification. In this regard, the Examiner's attention is directed to pages 5 and 6 of Applicants' disclosure. As note in the first full paragraph at page 6, to control the stability of the elastic limit ratio without fine wound deformation in the wire, elastic limit ratio rollers with a ratio D/d of 40 to 60 are necessary immediately following the vertical and transverse rollers shown. The presentation of claim 3 does not represent a separate invention as it includes the limitations from claim 2 which has been searched. There is no undue burden on the Examiner to consider the method at this stage in the prosecution. Applicants most respectfully submit that all the claims now present in the application are in full compliance with 35 U.S.C. 112 and are clearly patentable over the references of record.

The rejection of claims 1 and 2 under 35 U.S.C. 103(a) as being unpatentable over Shneerov et al. and Cary has been carefully considered but is most respectfully traversed. Applicants most respectfully submit that the combination of references does not establish a prima facie case of obviousness of the claimed invention. f

Applicants wish to direct the Examiner's attention to the basic requirements of a prima facie case of obviousness as set forth in the MPEP § 2143. This section states that to establish a prima facie case of obviousness, three basic criteria first must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the art, to modify the reference or to combine the reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.

The teaching or suggestion to make the claimed combination and the reasonable expectation of success must both be found in the prior art, not in applicant's disclosure. In re Vaeck, 947 F.2d 488, 20 USPQ2d 1438 (Fed. Cir. 1991).

Section 2143.03 states that all claim limitations must be taught or suggested by the prior art. In re Royka, 490 F.2d 981, 180 USPQ 580 (CCPA 1974). "All words in a claim must be considered in judging the patentability of that claim against the prior art." In re Wilson, 424 F.2d 1382, 1385, 165 USPQ 494, 496 (CCPA 1970). If an independent claim is nonobvious under 35 U.S.C. 103, then any claim depending therefrom is nonobvious. In re Fine, 837 F.2d 1071, 5 USPQ2d 1596 (Fed. Cir. 1988).

Applicants also most respectfully direct the Examiner's attention to MPEP § 2144.08 (page 2100-114) wherein it is stated that Office personnel should consider all rebuttal argument and evidence present by applicant and the citation of In re Soni for error in not considering evidence presented in the specification.

Applicants most respectfully submit that the presently claimed invention includes an arc welding solid wire whose surface comprises a copper plated film, wherein the elastic limit ratio (elastic limit/tensile strength) of the wire finally produced is controlled in the range between 50 and 88%, as claimed in claim 1.

Also, the invention claimed in claim 2 is that in the arc welding solid wire of claim 1, the elastic limit ratio is controlled by installing three to eight limit ratio control vertical rollers and three to eight limit ratio control transverse rollers which have a ratio D/d equal to 40 to 60 (where D is roller diameter and d is wire diameter) following coil control vertical and transverse rollers after final drawing. Claim 3 is more specifically to the method to produce the wire having a unique combination of properties using the roller ratio from claim 2.

The arc welding solid wire according to the present invention has mechanical property such as the elastic limit ratio (elastic limit/tensile strength) controlled in the range between 50 to 80%. This range is not suggested in the prior art and the importance of the range can be seen from Table 1 in Applicants specification.

As noted on page 3 of Applicants' specification to achieve the objectives of the present invention, wire feeding performance was closely examined from a new point of view. That is, the coil properties of a solid wire which is set free after extraction from the reel or the pail pack were compared with the coil properties when the wire is cut after the solid wire is freely fed from the welding tip portion with the welding stopped. From

this, it was discovered that wire extracted from the welding tip portion wherein the coil properties are in the specific predetermined range, has good stability and can be used in the welding with a good bead. Thus, the present invention is achieved by the discovery that the good stability is closely related to the elastic limit ratio (elastic limit: tensile strength) of the wire.

As further noted at the bottom of page 4 of Applicants' specification, as shown by the graphs in Fig. 3, solid wire is easily bent and there is a large change in the linearity of the wire or the diameter of free coil in proportion to the decrease in the elastic limit ratio. This disclosure shows for the first time that, contrary to such a tendency, welding performance is good when the elastic limit ratio is between 50 and 88%. The specification continues to discuss the discovery of the invention. Applicants wish to point out that the focus of Section 103 obviousness grounds must be whether the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made. Discovery of the problem is part of the subject matter as a whole inquiry and determination. See In re Kaslow 217 USPQ 1089 (CAFC). Clearly, there is no suggestion of the problem which Applicants' have discovered nor the solution as set forth in the presently claimed invention.

In this regard, the data presented in Applicants' specification must be taken into consideration (see in particular Table 1) which clearly demonstrates the importance of the claim limitations which are clearly not suggested by the prior art. Obvious to try is not the standard of obviousness under 35 U.S.C. 103.

Moreover, Applicants' specification may not be used as a teaching reference to arrive at the presently claimed invention from the prior art. In re Fritch, 23 USPQ 1780, 1784(Fed Cir. 1992) ("It is impermissible to engage in hindsight reconstruction of the claimed invention, using the applicant's structure as a template and selecting elements from references to fill the gaps.).

More particularly, Shneerov et al. '212 discloses a wire for welding having the ultimate strength that ranges from 830 to 1320 MPa, and Cary discloses the mechanical

properties that range from 450 to 830 MPa for tensile strengths and 390 to 740 MPa for yield strengths, cited by the Examiner.

However, the mechanical properties in Cary is not those of an welding wire but those of workpieces, which are welded by shielded metal arc welding (SMAW) electrodes listed in American Welding Society (AWS) and then tested. (See American Society Mechanical Engineers (ASME), copy enclosed.)

Also, as known from the above description, the mechanical property used in the present invention is the elastic limit ratio (elastic limit/tensile strength) as known from claim 1, but the mechanical properties used in Shneerov et al. and Cary are the ultimate strength, the tensile strength and the yield strength, respectively.

Therefore, the present invention is fully different from Cary, because Cary uses value obtained simply dividing the yield strengths into tensile strengths and the present invention uses the elastic limit ratio obtained by dividing the elastic limit into the tensile strength and controlled by the elastic limit control rollers. In addition, the ratio ranges of Shneerov et al. and Cary are within 10%, but the elastic limit used in the present invention can be controlled by approximately 40% using the elastic limit control rollers.

Accordingly, Applicants believe that the claims of the present invention are not obvious to one of ordinary skill in the art to which the invention pertains, and it is most respectfully requested that the rejection of claims 1 and 2 be withdrawn.

In view of the above comments, favorable reconsideration and allowance of all of the claims now present in the application are most respectfully requested.

Respectfully submitted,
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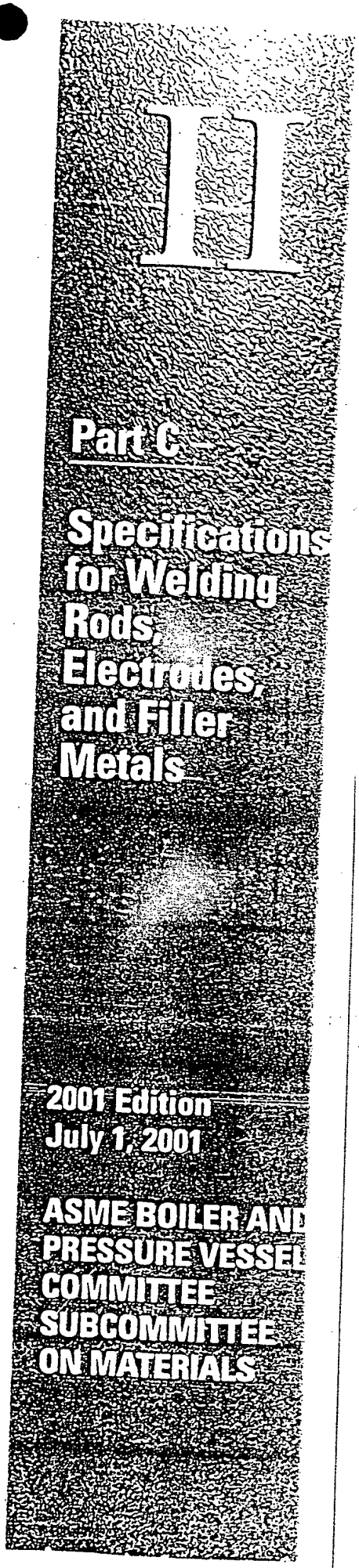
ASME BOILER AND PRESSURE VESSEL CODE
AN INTERNATIONAL CODE

MATERIALS

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS
NEW YORK, NEW YORK



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SPECIFICATION FOR CARBON STEEL ELECTRODES FOR SHIELDED METAL ARC WELDING (SMAW)

SFA-5.1

(Identical with AWS Specification A5.1-91)

1. Scope

This specification prescribes requirements for the classification of carbon steel electrodes for shielded metal arc welding.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The welding electrodes covered by this specification are classified according to the following:

(*1*) Type of current (see Table 1)
(*2*) Type of covering (see Table 1)
(*3*) Welding position (see Table 1)
(*4*) Mechanical properties of the weld metal in the as-welded or aged condition (see Tables 2 and 3)

2.2 Materials classified under one classification shall not be classified under any other classification of this specification, except that E7018M may also be classified as E7018 provided the electrode meets all of the requirements of both classifications.

3. Acceptance

Acceptance[1] of the welding electrodes shall be in accordance with the provisions of the ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*[2]

4. Certification

By affixing the AWS specification and classification designations to the packagings, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.[3]

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. Customary Units are the standard units of measure in this specification. The SI Units are given as equivalent values to the U.S. Customary Units. The standard sizes and dimensions in the two systems are not identical, and for this reason, conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded to the "nearest unit" of the last right-hand place of figures used in expressing the limiting value in accordance with the round-off method of ASTM Practice E29 for *Using Significant Digits in Test Data to Determine Conformance with Specifications.*[4]

---

[1] See A3 (in the Appendix) for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01 *Filler Metal Procurement Guidelines.*

[2] AWS standards can be obtained from the American Welding Society, 550 N.W. LeJeune Road, P.O. Box 351040, Miami, Florida 33135.

[3] See A4 (in the Appendix) for further information concerning certification and the testing called for to meet this requirement.

[4] ASTM standards can be obtained from the American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshohocken, PA 19428-2959.

TABLE 1
ELECTRODE CLASSIFICATION

AWS Classification	Type of Covering	Welding Position[a]	Type of Current[b]
E6010	High cellulose sodium	F, V, OH, H	dcep
E6011	High cellulose potassium	F, V, OH, H	ac or dcep
E6012	High titania sodium	F, V, OH, H	ac or dcen
E6013	High titania potassium	F, V, OH, H	ac, dcep or dcen
E6019	Iron oxide titania potassium	F, V, OH, H	ac, dcep or dcen
E6020	High iron oxide	H-fillets, F	ac or dcen, ac, dcep or dcen
E6022[c]	High iron oxide	F, H	ac or dcen
E6027	High iron oxide, iron powder	H-fillets, F	ac or dcen, ac, dcep or dcen
E7014	Iron powder, titania	F, V, OH, H	ac, dcep or dcen
E7015[d]	Low hydrogen sodium	F, V, OH, H	dcep
E7016[d]	Low hydrogen potassium	F, V, OH, H	ac or dcep
E7018[d]	Low hydrogen potassium, iron powder	F, V, OH, H	ac or dcep
E7018M	Low hydrogen iron powder	F, V, OH, H	dcep
E7024[d]	Iron powder, titania	H-fillets, F	ac, dcep or dcen
E7027	High iron oxide, iron powder	H-fillets, F	ac or dcen, ac, dcep or dcen
E7028[d]	Low hydrogen potassium, iron powder	H-fillets, F	ac or dcep
E7048[d]	Low hydrogen potassium, iron powder	F, V, OH, H, V-down	ac or dcep

Notes:

a. The abbreviations indicate the welding positions as follows:
F = Flat
H = Horizontal
H-fillets = Horizontal fillets
V-down = Vertical with downward progression

V = Vertical, OH = Overhead } { For electrodes $^{3}/_{16}$ in. (4.8 mm) and under, except $^{5}/_{32}$ in. (4.0 mm) and under for classifications E7014, E7015, E7016, E7018, and E7018M.

b. The term "dcep" refers to direct current electrode positive (dc, reverse polarity). The term "dcen" refers to direct current electrode negative (dc, straight polarity).

c. Electrodes of the E6022 classification are intended for single-pass welds only.

d. Electrodes with supplemental elongation, notch toughness, absorbed moisture, and diffusible hydrogen requirements may be further identified as shown in Tables 2, 3, 10, and 11.

TABLE 2
TENSION TEST REQUIREMENTS[a,b,c]

AWS Classification	Tensile Strength		Yield Strength at 0.2% Offset		Elongation in 2 in. (50.8 mm) Percent
	ksi	MPa	ksi	MPA	
E6010	60	414	48	331	22
E6011	60	414	48	331	22
E6012	60	414	48	331	17
E6013	60	414	48	331	17
E6019	60	414	48	331	22
E6020	60	414	48	331	22
E6022[d]	60	414	not specified		not specified
E6027	60	414	48	331	22
E7014	70	482	58	399	17
E7015	70	482	58	399	22
E7016	70	482	58	399	22
E7018	70	482	58	399	22
E7024	70	482	58	399	17[e]
E7027	70	482	58	399	22
E7028	70	482	58	399	22
E7048	70	482	58	399	22
E7018M	note g	482	53–72[f]	365–496[f]	24

Notes:
a. See Table 4 for sizes to be tested.
b. Requirements are in the as-welded condition with aging as specified in 11.3.
c. Single values are minimum.
d. A transverse tension test, as specified in 11.2 and Figure 9 and a longitudinal guided bend test, as specified in Section 12, Bend Test, and Figure 10, are required.
e. Weld metal from electrodes identified as E7024-1 shall have elongation of 22% minimum.
f. For $\frac{3}{32}$ in. (2.4 mm) electrodes, the maximum for the yield strength shall be 77 ksi (531 MPa).
g. Tensile strength of this weld metal is a nominal 70 ksi (482 MPa).

PART B — TESTS, PROCEDURES, AND REQUIREMENTS

6. Summary of Tests

The tests required for each classification are specified in Table 4. The purpose of these tests is to determine the chemical composition, mechanical properties, and soundness of the weld metal; moisture content of the low hydrogen electrode covering; and the usability of the electrode. The base metal for the weld test assemblies, the welding and testing procedures to be employed, and the results required are given in Sections 8 through 17.

The supplemental tests for absorbed moisture, in Section 16, Absorbed Moisture Test, and diffusible hydrogen, in Section 17, Diffusible Hydrogen Test, are not required for classification of the low hydrogen electrodes except for E7018M, where these are required. See Notes j and n of Table 4.

7. Retest

If the results of any tests fail to meet the requirement, that test shall be repeated twice. The results of both tests shall meet the requirement. Specimens for retest may be taken from the original test assembly or from a new test assembly. For chemical analysis, retest need be only for those specific elements that failed to meet the test requirement.

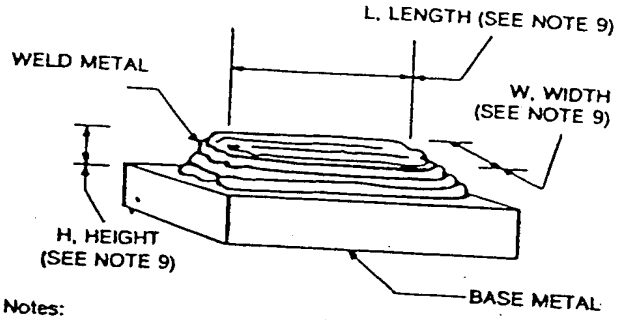
8. Weld Test Assemblies

8.1 One or more of the following five weld test assemblies are required.

(*1*) The weld pad in Fig. 1 for chemical analysis of the undiluted weld metal

(2) The groove weld in Fig. 2 for mechanical properties and soundness of the weld metal

(*3*) The fillet weld in Fig. 3 for the usability of the electrode



Notes:

1. Base metal of any convenient size, of any type specified in Table 5, shall be used as the base for the weld pad.
2. The surface of the base metal on which the filler metal is to be deposited shall be clean.
3. The pad shall be welded in the flat position with successive layers to obtain undiluted weld metal.
4. One pad shall be welded for each type of current shown in Table 4 except for those classifications identified by note L in Table 4.
5. The number and size of the beads will vary according to the size of the electrode and the width of the weave, as well as the amperage employed.
6. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C).
7. The slag shall be removed after each pass.
8. The test assembly may be quenched in water between passes to control interpass temperature.
9. The minimum completed pad size shall be at least four layers in height (H) with length (L) and width (W) sufficient to perform analysis. The sample for analysis shall be taken at least 1/4 in. (6.4 mm) above the original base metal surface.

FIG. 1 PAD FOR CHEMICAL ANALYSIS OF UNDILUTED WELD METAL

the assemblies shall be as prescribed in Sections 9 through 14.

Electrodes other than low hydrogen electrodes shall be tested without "conditioning." Low hydrogen electrodes, if they have not been adequately protected against moisture pickup in storage, shall be held at a temperature of 500 to 800°F (260 to 427°C) for a minimum of one hour prior to testing.

8.3 **Weld Pad.** A weld pad, when required, shall be prepared as specified in Fig. 1. Base metal of any convenient size of the type specified in Table 5 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C). The slag shall be removed after each pass. The pad may be quenched in water between passes. The dimensions of the completed pad shall be as shown in Fig. 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Figs. 2 or 5 using base metal of the appropriate type specified in Table 5. Testing of this assembly shall be as specified in Section 11, Tension Test, and Section 13, Impact Test. The assembly shall be tested in the as-welded or aged condition.

8.4.2 Transverse Tension and Bend Tests. A test assembly shall be prepared and welded as specified in Fig. 4 using base metal of the appropriate type specified in Table 5. Testing of this assembly shall be as specified in 11.2 through 11.4 and Section 12, Bend Test. The assembly shall be tested in the aged condition.

8.5 **Fillet Weld.** A test assembly shall be prepared and welded as specified in Table 4 and Fig. 3 using base metal of the appropriate type specified in Table 5. The welding positions shall be as specified in Table 6 and Figs. 3 and 6 according to the size and classification of electrode. Testing of the assembly shall be as specified in Section 14, Fillet Weld Test.

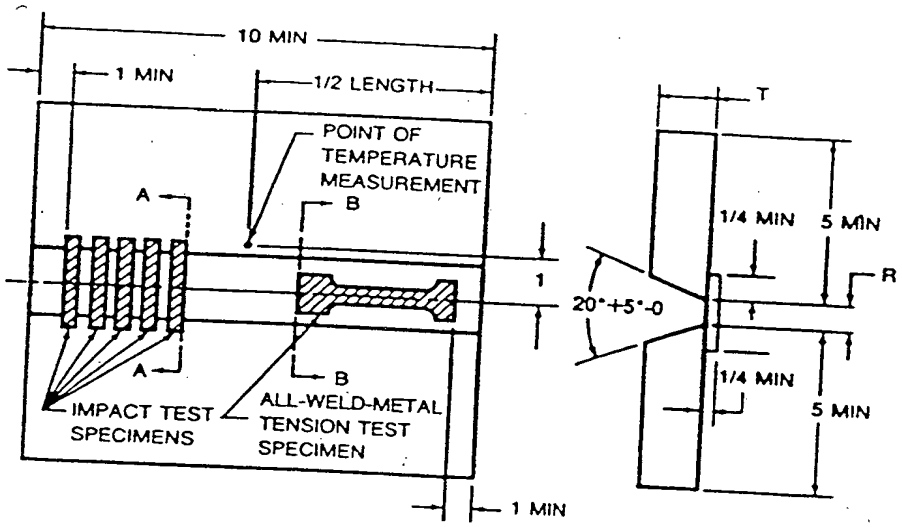
9. Chemical Analysis

9.1 The sample for analysis shall be taken from weld metal obtained with the electrode. The sample shall come from a weld pad or from a low dilution area in the fractured all-weld-metal tension specimen or the groove weld in Figs. 2 or 5. Areas where arc starts or craters exist shall be avoided.

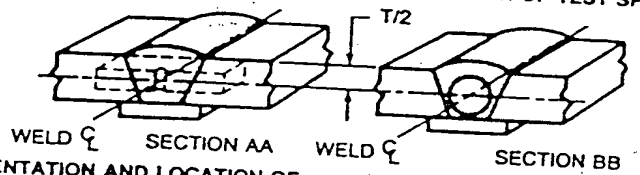
The top surface of the pad described in 8.3 and shown in Fig. 1 shall be removed and discarded, and a sample for analysis shall be obtained from the underlying metal by any appropriate mechanical means. The sample shall be free of slag and shall be taken at least 1/4 in. (6.4 mm) from the nearest surface of the base metal.

The low dilution area in the fractured tension test specimen or in the groove weld in Figs. 2 or 5 shall be prepared for analysis by any suitable mechanical means.

9.2 The sample shall be analyzed by accepted analytical methods. The referee method shall be ASTM Standard Method E350, *Chemical Analysis of Carbon Steel.*



(A) TEST ASSEMBLY SHOWING LOCATION OF TEST SPECIMEN



(B) ORIENTATION AND LOCATION OF IMPACT TEST SPECIMEN

(C) LOCATION OF ALL-WELD-METAL TENSION TEST SPECIMEN

SI Equivalents

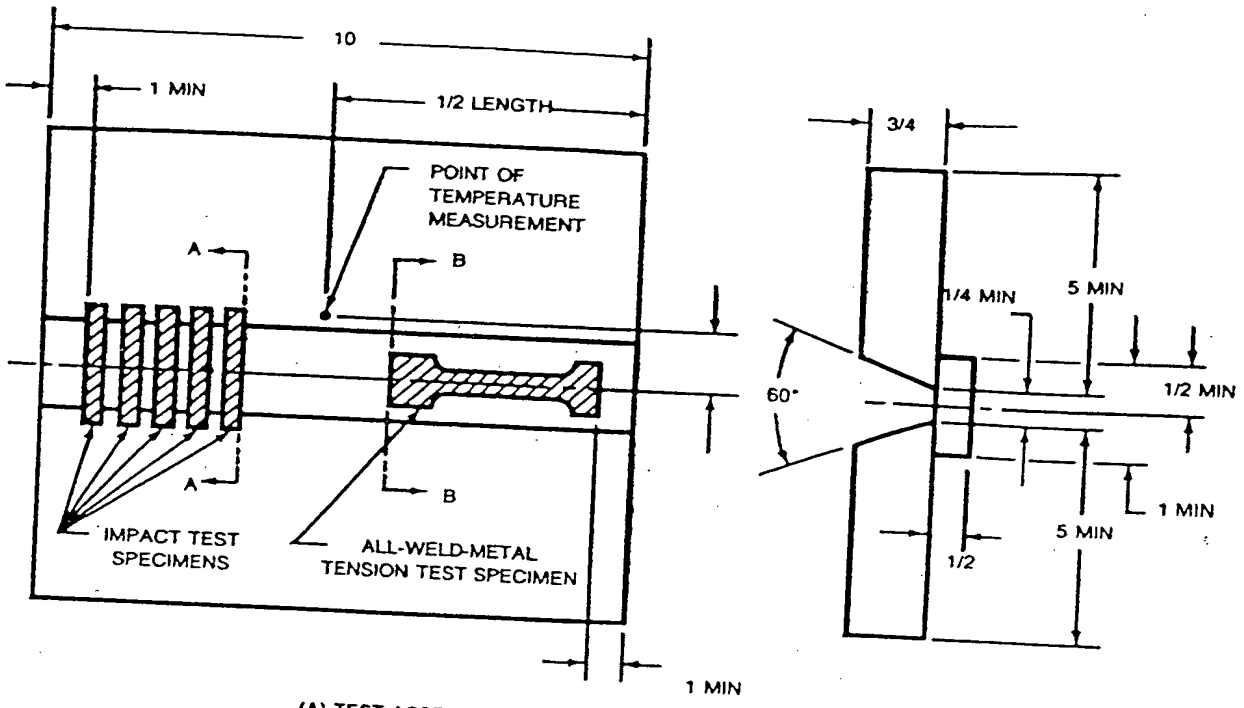
in.	mm
1/4	6.4
1	25
5	127
10	254

Electrode Size in.	Electrode Size mm	(T) Plate Thickness in.	(T) Plate Thickness mm	(R) Root Opening in.	(R) Root Opening mm	Passes Per Layer	Total Layers
3/32	2.4	1/2	13	3/8	10	2	not specified
1/8	3.2	1/2	13	1/2	13	2	5 to 7
5/32	4.0	3/4	20	5/8	16	2	7 to 9
3/16	4.8	3/4	20	3/4	20	2	6 to 8
7/32	5.6	3/4	20	7/8	23	2	6 to 8
1/4	6.4	1	25	1	25	2	9 to 11
5/16	8.0	1-1/4	32	1-1/8	28	2	10 to 12

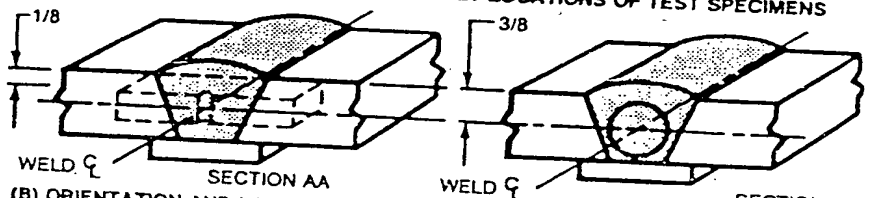
Notes:

1. All dimensions except angles are in inches.
2. For electrodes longer than 18 in. (450 mm), a 20 in. (500 mm) minimum length test assembly shall be welded.
3. Base metal shall be as specified in Table 5.
4. The surfaces to be welded shall be clean.
5. Prior to welding, the assembly may be preset to yield a welded joint sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5 deg of plane. A welded test assembly that is more than 5 deg out of plane shall be discarded. Straightening of the test assembly is prohibited.
6. Welding shall be in the flat position, using each type of current specified in Table 4 except for classifications identified by Note L in Table 4.
7. The preheat temperature shall be 225°F (105°C) minimum. The interpass temperature shall not be less than 225°F (105°C) nor more than 350°F (175°C).
8. The joint root may be seal welded with 3/32 or 1/8 in. (2.4 or 3.2 mm) electrodes using stringer beads.
9. In addition to the stops and starts at the ends, each pass shall contain a stop and start in between the ends.
10. The completed weld shall be at least flush with the surface of the test plate.

FIG. 2 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES AND SOUNDNESS EXCEPT FOR E6022 AND E7018M ELECTRODES



(A) TEST ASSEMBLY LOCATIONS OF TEST SPECIMENS



(B) ORIENTATION AND LOCATION OF IMPACT TEST SPECIMEN

(C) LOCATION OF ALL-WELD-METAL TENSION TEST SPECIMEN

SI Equivalents	
in.	mm
1/8	3.2
1/4	6.4
3/8	9.5
1/2	12.7
3/4	19.1
1	25.4
5	127
10	254

Notes:

1. All dimensions except angles are in inches.
2. Base metal shall be as specified in Table 5.
3. The surfaces to be welded shall be clean.
4. Prior to welding, the assembly may be preset to yield a welded joint sufficiently flat to facilitate removal of the test specimens. As an alternative, restraint or a combination of restraint and presetting may be used to keep the welded joint within 5 deg of plane. A welded test assembly that is more than 5 deg out of plane shall be discarded. Straightening of the test assembly is prohibited.
5. The assembly shall be welded in the vertical position with progression upward for electrodes 5/32 in. (4.0 mm) and less in size, and in the flat position for electrodes 3/16 in. (4.8 mm) and greater in size, using the type of current specified in Table 4 for the electrode and welding technique recommended by the electrode manufacturer.
6. The preheat temperature and the interpass temperature shall be 200-250°F (93-121°C).
7. The welding heat input shall be 30 to 40 kJ/in. (12 to 16 kJ/cm) for the 3/32 in. (2.4 mm) size electrodes and 50 to 60 kJ/in. (20 to 24 kJ/cm) for the 1/8 in. (3.2 mm) size and larger electrodes.
8. In addition to the stops and starts at the ends, each pass shall contain a stop and start in between the ends.
9. The completed weld shall be at least flush with the surface of the test plate. Maximum weld reinforcement shall be 3/16 in. (4.8 mm). Peening of weld beads is not permitted.

FIG. 5 GROOVE WELD TEST ASSEMBLY FOR MECHANICAL PROPERTIES AND SOUNDNESS OF WELD METAL MADE WITH E7018M ELECTRODES

TABLE 5
BASE METAL FOR TEST ASSEMBLIES

AWS Classification	Base Metal		
	Type	ASTM Specification[a]	UNS Number[b]
All	Carbon steel	A131 Grade B	K02102
		A285 Grade A	K01700
		A285 Grade B	K02200
All except E7018M	Carbon steel	A285 Grade C	K02801
		A283 Grade D	—
		A36	K02600
		A29 Grade 1015	G10150
		A29 Grade 1020	G10200

NOTES:
a. Equivalent steel may be used.
b. SAE/ASTM Unified Numbering System for Metals and Alloys.

Low Alloy Steel, Silicon Electrical Steel, Ingot Iron and Wrought Iron.

9.3 The results of the analysis shall meet the requirements of Table 7 for the classification of electrode under test.

10. Radiographic Test

10.1 When required in Table 4, the groove weld described in 8.4.1 and shown in Fig. 2 or 5 shall be radiographed to evaluate the soundness of the weld metal. In preparation for radiography, the backing shall be removed, and both surfaces of the weld shall be machined or ground smooth. The finished surface of the weld may be flush with the plate or have a reasonably uniform reinforcement not exceeding $\frac{3}{32}$ in. (2.4 mm). Both surfaces of the test assembly in the area of the weld shall be smooth enough to avoid difficulty in interpreting the radiograph.

10.2 The weld shall be radiographed in accordance with ASTM Method E142, *Controlling Quality of Radiographic Testing*. The quality level of inspection shall be 2-2T.

10.3 The soundness of the weld metal meets the requirements of this specification if the radiograph shows the following:

(*1*) No cracks, no incomplete fusion or incomplete joint penetration

(2) No slag inclusions longer than $\frac{1}{4}$ in. (6.4 mm) or $\frac{1}{3}$ of the thickness of the weld, whichever is greater, or no groups of slag inclusions in line that have an aggregate length greater than the thickness of the weld in a length 12 times the thickness of the weld, except when the distance between the successive inclusions exceeds 6 times the length of the longest inclusions in the group.

(*3*) No rounded indications in excess of those permitted by the radiographic standards in Fig. 7 according to the grade specified in Table 8.

One in. (25 mm) of the weld measured from each end of the assembly shall be excluded from radiographic evaluation.

10.4 A rounded indication is an indication (on the radiograph) whose length is no more than three times its width. Rounded indications may be circular, elliptical, conical, or irregular in shape, and they may have "tails." The size of a rounded indication is the largest dimension of the indication, including any tail that may be present.

The indication may be porosity or slag. Indications whose largest dimension does not exceed $\frac{1}{64}$ in. (0.4 mm) shall be disregarded. Test assemblies with porosity indications larger than the largest rounded indications permitted in the radiographic standards do not meet the requirements of this specification.

11. Tension Test

11.1 One all-weld-metal tension test specimen shall be machined from the groove weld described in 8.4.1 as shown in Fig. 2 or 5. The dimensions of the specimen shall be as shown in Fig. 8.

11.2 For E6022 electrodes, one traverse tension test specimen shall be machined from the groove weld

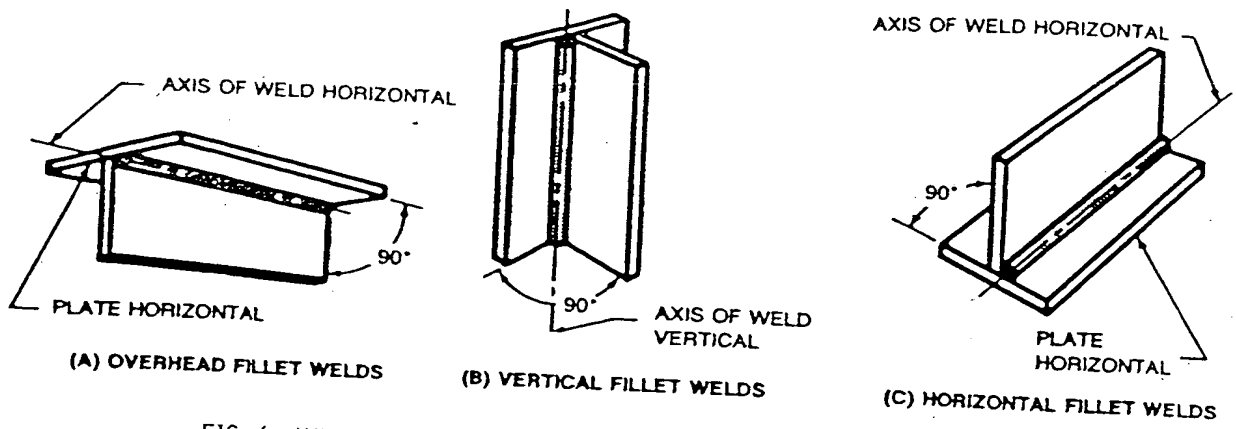


FIG. 6 WELDING POSITIONS FOR FILLET WELD TEST ASSEMBLIES

described in 8.4.2 and Fig. 4. The dimensions of the specimen shall be as shown in Fig. 9.

11.3 The tension specimens for all electrodes except the low hydrogen classifications shall be aged at 200 to 220°F (95 to 105°C) for 48 ±2 hours, and cooled in air to room temperature. All specimens shall be tested in the manner described in the tension testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.*

11.4 The results of the tension test shall meet the requirements specified in Table 2.

12. Bend Test (For E6022 Electrodes Only)

12.1 One longitudinal face bend specimen, as required in Table 4, shall be machined from the groove weld test assembly described in 8.4.2 and shown in Fig. 4. Dimensions of the specimen shall be as shown in Fig. 10.

12.2 The bend specimen shall be aged at 200 to 220°F (95 to 105°C) for 48 ±2 hours then air cooled to room temperature and tested as required in 12.3.

12.3 The specimen shall be tested in the manner described in the bend testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.* The specimen shall be bent uniformly through 180 degrees over a $\frac{3}{4}$ in. (19 mm) radius in any suitable jig. Three standard jigs are shown in Fig. 11. Positioning of the face bend specimen shall be such that the weld face of the last side welded is in tension.

12.4 Each specimen, after bending, shall conform to the $\frac{3}{4}$ in. (19 mm) radius, with an appropriate allowance for springback and the weld metal shall not contain openings in excess of $\frac{1}{8}$ in. (3.2 mm) on the convex surface.

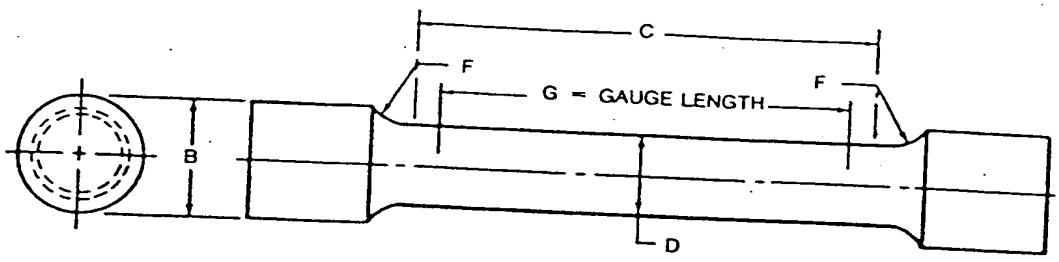
13. Impact Test

13.1 Five Charpy V-notch impact test specimens, Fig. 12, shall be machined from the test assembly shown in Fig. 2 or 5, for those classifications for which impact testing is required in Table 4.

13.2 The five specimens shall be tested in accordance with the fracture toughness testing section of AWS B4.0, *Standard Methods for Mechanical Testing of Welds.* The test temperature shall be that specified in Table 3 for the classification under test.

13.3 In evaluating the test results for all the classifications that require impact testing, except E7018M, the lowest and highest values obtained shall be disregarded. Two of the three remaining values shall equal, or exceed, the specified 20 ft-lb (27J) energy level. One of the three may be lower, but not lower than 15 ft-lb (20J). The average of the three shall not be less than the required 20 ft-lb (27J) energy level.

13.4 In evaluating the results for E7018M, all five values shall be used. Four of the five values shall equal, or exceed, the specified 50 ft-lb (67J) energy level. One of the five may be lower, but not lower than 40 ft-lb (54J). The average of the five shall not be less than the required 50 ft-lb (67J) energy level.

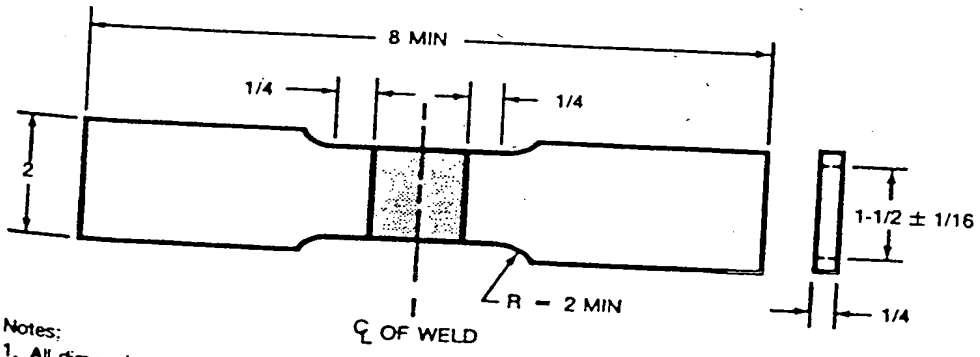


Dimensions of Specimen, in.					
Test Plate Thickness	D	G	C	B	F, Min.
1/2	0.250 ± 0.005	1.000 ± 0.005	1-1/4	3/8	3/16
3/4 and larger	0.500 ± 0.010	2.000 ± 0.005	2-1/4	3/4	3/8

Dimensions of Specimen, mm					
Test Plate Thickness	D	G	C	B	F, Min.
12.7	6.40 ± 0.13	25.40 ± 0.13	32	9.5	4.8
19 and larger	12.70 ± 0.25	50.80 ± 0.13	57	19	9.5

Notes:
1. Dimensions G and C shall be as shown, but ends may be of any shape to fit the testing machine holders as long as the load is axial.
2. The diameter of the specimen within the gauge length shall be slightly smaller at the center than at the ends. The difference shall not exceed one percent of the diameter.
3. When the extensometer is required to determine yield strength, dimension C may be modified. However, the percent of the elongation shall be based on dimension G.
4. The surface finish within the C dimension shall be no rougher than 63 μ in. (1.6 μ m).

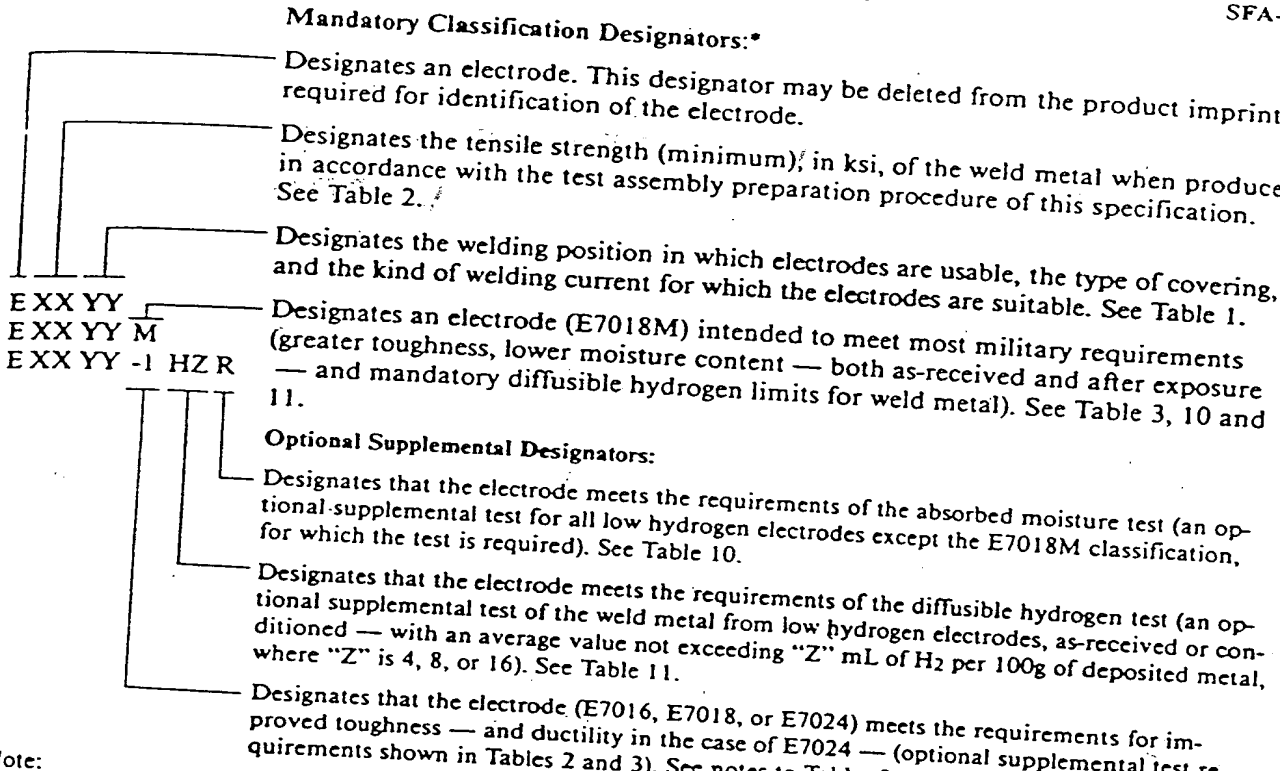
FIG. 8 ALL-WELD-METAL TENSION TEST SPECIMEN DIMENSIONS



SI Equivalents	
in.	mm
1/4	6.4
1-1/2 ± 1/16	38.1 ± 1.6
2	51
8	203

Notes:
1. All dimensions are in inches.
2. Weld reinforcement shall be ground or machined smooth and flush with the surfaces of the specimen. Grinding or machining marks shall be parallel of the longest dimension of the specimen.

FIG. 9 TRANSVERSE TENSION TEST SPECIMEN (E6022)



Note:
* The combination of these designators constitutes the electrode classification.

FIG. 16 ORDER OF ELECTRODE MANDATORY AND OPTIONAL SUPPLEMENTAL DESIGNATORS

print on all packages of electrodes, including individual unit packages enclosed within a larger package.

WARNING:

• Protect yourself and others. Read and understand this information. FUMES AND GASES can be dangerous to your health. ARC RAYS can injure eyes and burn skin. ELECTRIC SHOCK can kill.

- Before use, read and understand the manufacturer's instructions, Material Safety Data Sheets (MSDSs), and your employer's safety practices.
- Keep your head out of the fumes.
- Use enough ventilation, exhaust at the arc, or both, to keep fumes and gases away from your breathing zone, and the general area.
- Wear correct eye, ear, and body protection.
- Do not touch electrical parts.
- See American National Standard Z49.1, *Safety in Welding and Cutting*, published by the American Welding Society, 550 North LeJeune Road, P.O. Box 351040, Miami, Florida, 33135; *OSHA Safety and Health Standards*, 29 CFR 1910, available from the U.S. Government Printing Office, Washington, D.C. 20402.

DO NOT REMOVE THIS INFORMATION

SPECIFICATION FOR LOW-ALLOY STEEL ELECTRODES FOR SHIELDED METAL ARC WELDING

SFA-5.5

(Identical with AWS Specification A5.5-96.)

1. Scope

This specification prescribes requirements for the classification of low-alloy steel electrodes for shielded metal arc welding of carbon and low-alloy steels. These electrodes include steel alloys in which no single alloying element exceeds 10.5 percent.

PART A — GENERAL REQUIREMENTS

2. Classification

2.1 The welding electrodes covered by this specification are classified according to the following:

(a) Type of current (Table 1)
(b) Type of covering (Table 1)
(c) Welding position (Table 1)
(d) Chemical composition of the weld metal (Table 2)
(e) Mechanical properties of the weld metal in the as-welded or postweld heat-treated condition (Tables 3 and 4)

2.2 Material classified under one classification shall not be classified under any other classification in this specification.

3. Acceptance

Acceptance[1] of the welding electrode shall be in accordance with the provisions of the ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

[1] See Section A3, Acceptance (in the Appendix), for further information concerning acceptance, testing of the material shipped, and ANSI/AWS A5.01, *Filler Metal Procurement Guidelines.*

4. Certification

By affixing the AWS specification and classification designations to the packaging, or the classification to the product, the manufacturer certifies that the product meets the requirements of this specification.[2]

5. Units of Measure and Rounding-Off Procedure

5.1 U.S. customary units are the standard units of measure in this specification. The SI units are given as equivalent values to the U.S. customary units. The standard sizes and dimensions in the two systems are not identical and for this reason conversion from a standard size or dimension in one system will not always coincide with a standard size or dimension in the other. Suitable conversions, encompassing standard sizes of both, can be made, however, if appropriate tolerances are applied in each case.

5.2 For the purpose of determining conformance with this specification, an observed or calculated value shall be rounded "to the nearest unit" in the last right-hand place of figures used in expressing the limiting value in accordance with the rounding-off rules given in ASTM E29, *Standard Practice for Using Significant Digits in Test Data to Determine Conformance with Specifications.*

[2] See Section A4, Certification (in the Annex), for further information concerning certification and the testing called for to meet this requirement.

TABLE 3
TENSION TEST REQUIREMENTS[a,b]

AWS Classification[c]	Tensile Strength, ksi	Tensile Strength, MPa	Yield Strength, at 0.2% Offset, ksi	Yield Strength, at 0.2% Offset, MPa	Elongation Percent	Postweld Condition[d]
E7010-P1	70	480	60	415	22	AW
E7010-A1	70	480	57	390	22	PWHT
E7010-G	70	480	57	390	22	AW or PWHT
E7011-A1	70	480	57	390	22	PWHT
E7011-G	70	480	57	390	22	AW or PWHT
E7015-X	70	480	57	390	25	PWHT
E7015-B2L	75	520	57	390	19	PWHT
E7015-G	70	480	57	390	25	AW or PWHT
E7016-X	70	480	57	390	25	PWHT
E7016-B2L	75	520	57	390	19	PWHT
E7016-G	70	480	57	390	25	AW or PWHT
E7018-X	70	480	57	390	25	PWHT
E7018-B2L	75	520	57	390	19	PWHT
E7018-C3L	70	480	57	390	25	AW
E7018-W1	70	480	60	415	25	AW
E7018-G	70	480	57	390	25	AW or PWHT
E7020-A1	70	480	57	390	25	PWHT
E7020-G	70	480	57	390	25	AW or PWHT
E7027-A1	70	480	57	390	25	PWHT
E7027-G	70	480	57	390	25	AW or PWHT
E8010-P1	80	550	67	460	19	AW
E8010-G	80	550	67	460	19	AW or PWHT
E8011-G	80	550	67	460	19	AW or PWHT
E8013-G	80	550	67	460	16	AW or PWHT
E8015-X	80	550	67	460	19	PWHT
E8015-B3L	80	550	67	460	17	PWHT
E8015-G	80	550	67	460	19	AW or PWHT
E8016-X	80	550	67	460	19	PWHT
E8016-C3	80	550	68 to 80[e]	470 to 550[e]	24	AW
E8016-C4	80	550	67	460	19	AW
E8016-G	80	550	67	460	19	AW or PWHT
E8018-X	80	550	67	460	19	PWHT
E8018-B3L	80	550	67	460	17	PWHT
E8018-C3	80	550	68 to 80[e]	470 to 550[e]	24	AW
E8018-C4	80	550	67	460	19	AW
E8018-NM1	80	550	67	460	19	AW
E8018-W2	80	550	67	460	19	AW
E8018-G	80	550	67	460	19	AW or PWHT
E9010-G	90	620	77	530	17	AW or PWHT
E9011-G	90	620	77	530	17	AW or PWHT
E9013-G	90	620	77	530	14	AW or PWHT
E9015-X	90	620	77	530	17	PWHT
E9015-G	90	620	77	530	17	AW or PWHT
E9016-X	90	620	77	530	17	PWHT
E9016-G	90	620	77	530	17	AW or PWHT
E9018M	90	620	78 to 90[e]	540 to 620[e]	24	AW
E9018-X	90	620	77	530	17	PWHT
E9018-G	90	620	77	530	17	AW or PWHT

TABLE 3 (CONT'D)
TENSION TEST REQUIREMENTS[a,b]

AWS Classification[c]	Tensile Strength, ksi	Tensile Strength, MPa	Yield Strength, at 0.2% Offset, ksi	Yield Strength, at 0.2% Offset, MPa	Elongation Percent	Postweld Condition[d]
E10010-G	100	690	87	600	16	AW or PWHT
E10011-G	100	690	87	600	16	AW or PWHT
E10013-G	100	690	87	600	13	AW or PWHT
E10015-X	100	690	87	600	16	PWHT
E10015-G	100	690	87	600	16	AW or PWHT
E10016-X	100	690	87	600	16	PWHT
E10016-G	100	690	87	600	16	AW or PWHT
E10018M	100	690	88 to 100	610 to 690[e]	20	AW
E10018-X	100	690	87	600	16	PWHT
E10018-G	100	690	87	600	16	AW or PWHT
E11010-G	110	760	97	670	15	AW or PWHT
E11011-G	110	760	97	670	15	AW or PWHT
E11013-G	110	760	97	670	13	AW or PWHT
E11015-G	110	760	97	670	15	AW or PWHT
E11016-G	110	760	97	670	15	AW or PWHT
E11018-G	110	760	97	670	15	AW or PWHT
E11018M	110	760	98 to 110	680 to 760[e]	20	AW
E12010-G	120	830	107	740	14	AW or PWHT
E12011-G	120	830	107	740	14	AW or PWHT
E12013-G	120	830	107	740	11	AW or PWHT
E12015-G	120	830	107	740	14	AW or PWHT
E12016-G	120	830	107	740	14	AW or PWHT
E12018-G	120	830	107	740	14	AW or PWHT
E12018M	120	830	108 to 120	745 to 830[e]	18	AW
E12018M1	120	830	108 to 120	745 to 830[e]	18	AW

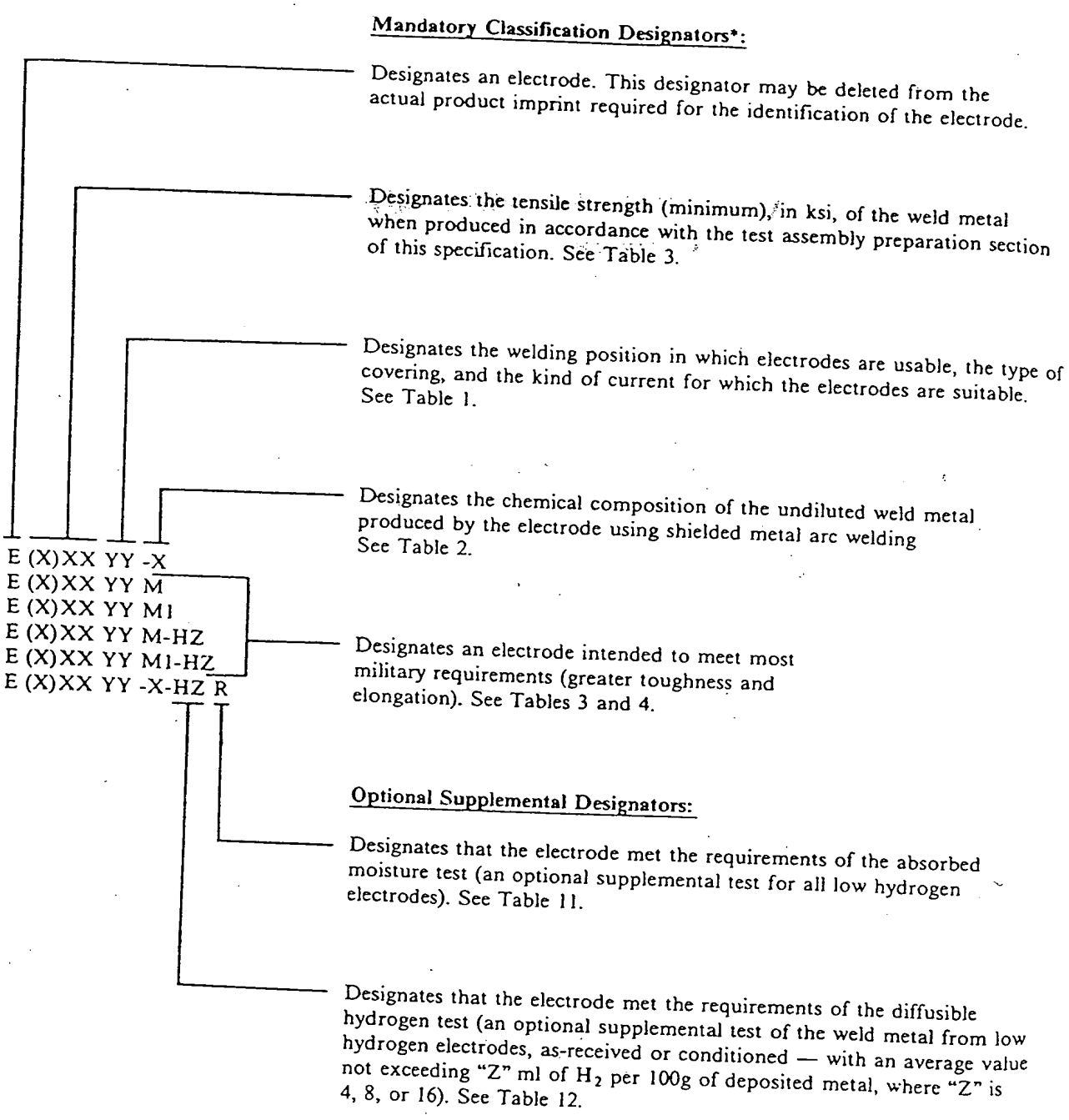
NOTES:
a. See Table 5 for sizes to be tested.
b. Single values are minimum, except as otherwise specified.
c. The letter suffix "X" as used in this table represents the suffixes (A1, B1, B2, etc.) except for those classifications which are tested in the as-welded condition.
d. "AW" signifies as-welded with aging when it is specified in 11.2, "PWHT" signifies postweld heat treated as specified in 8.4.2 and in Table 7, except that the "G" designated classifications, marked as "AW or PWHT" in this table, may have weld metal tested with or without PWHT as agreed between the supplier and purchaser.
e. For $\frac{3}{32}$ in. (2.4 mm) electrodes, the upper value for the yield strength may be 5 ksi (35 MPa) higher than the indicated value.

hydrogen electrodes, that have not been adequately protected against moisture absorption in storage, shall be held at a temperature of 500° to 800°F (260° to 427°C) for a minimum of one hour prior to testing.

8.3 Weld Pad. A weld pad, when required, shall be prepared as specified in Fig. 1. Base metal of any convenient size of the type specified in Table 6 shall be used as the base for the weld pad. The surface of the base metal on which the filler metal is deposited shall be clean. The pad shall be welded in the flat position with multiple layers to obtain undiluted weld metal. The preheat temperature shall not be less than 60°F (16°C) and the interpass temperature shall not exceed 300°F (150°C). Each weld pass shall be a single straight pass with the pass width not exceeding 2½ times the diameter of the core wire. The slag shall be removed after each pass. The pad may be quenched in water between passes. The dimensions of the completed pad shall be as shown in Fig. 1. Testing of this assembly shall be as specified in Section 9, Chemical Analysis.

8.4 Groove Weld

8.4.1 Mechanical Properties and Soundness. A test assembly shall be prepared and welded as specified in Fig. 2 or 4 using base metal of the appropriate type specified in Table 6, of thickness specified in Fig. 2 or 4. Testing of this assembly shall be as specified in



*The combination of these designators constitutes the electrode classification.

FIG. 12 ORDER OF ELECTRODE MANDATORY AND OPTIONAL SUPPLEMENTAL DESIGNATORS